CLAIMS:

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent is:

1. An apparatus for attenuating optical signals communicated in an optical network comprising:

optical signal generator for generating optical signals, each optical signal having a peaked spectrum function including a center wavelength;

an optical filter element for receiving and filtering an optical signal, said optical filter element exhibiting a peaked passband function including a center wavelength; and,

a wavelength-locked loop servo-control circuit for enabling real time alignment of said optical signal center wavelength with said peaked passband function of said optical filter, said optical signal center wavelength capable of being aligned at a wavelength corresponding to maximum overlap with said center wavelength of said peaked passband function of said optical filter for maximum transfer of said output optical signal by said filter element and minimum overlap with said peaked passband function of said optical filter so that said output optical signal may be attenuated in said optical system.

2. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 1, wherein said wavelength-locked loop servo-control circuit comprises:

a mechanism for applying a dither modulation signal at a dither modulation frequency to said optical signal to generate a dither modulated optical signal through said optical filter element;

a mechanism for converting a portion of dither modulated optical signal to into an electric feedback signal;

a mechanism for continuously comparing said feedback signal with said dither modulation signal and generating an error signal representing a difference between a frequency characteristic of said feedback signal and a dither modulation frequency; and

a mechanism responsive to said error signal for adjusting the peak spectrum function of said optical signal according to a desired amount of optical signal attenuation, wherein said center wavelength of said optical signal is adjusted to comprise a center wavelength ranging between said maximum overlap and minimum overlap with said center wavelength of said peaked passband function of said optical filter.

3. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 2, wherein said center wavelength of said optical signal becomes aligned for maximum overlap with said center wavelength of said peaked passband function of said optical filter when said frequency characteristic of said feedback error signal is two times said dither modulation frequency.

4. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 2, wherein said optical signal is a laser signal, said optical signal generator comprising:

laser diode device for generating a laser signal; and,

a laser bias control device for providing a bias signal to said laser diode device for adjusting the peak spectrum function of said laser signal, wherein said bias control device receives said error signal and adjusts said laser bias signal according to a value of error signal plus an offset corresponding to a desired amount of optical signal attenuation.

5. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 4, wherein said laser bias control device includes look-up table

comprising values of error signals mapped to laser bias signal values corresponding to desired degrees of attenuation, said center wavelength of said optical signal being adjusted in accordance with said mapped laser bias signal values.

6. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 2, wherein said converting mechanism comprises a photodetector device.

7. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 6, wherein said photodetector device is a p-i-n diode.

8. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 2, wherein said device for comparing includes a mixer device capable of combining said converted feedback signal with said dither modulation signal and generating a cross-product signal having components representing a sum and difference at dither frequencies.

9. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 7, further including:

low-pass filter device for filtering said cross-product signal; and

integrator circuit for averaging said output cross-product signal to generate said error signal, whereby said error signal is positive or negative depending on whether a center wavelength of said optical signal is respectively less than or greater than said center wavelength of said optical filter.

10. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 8, further including digitizer device for digitizing said error signal prior to input to said laser bias control device.

11. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 2, employed in a wavelength division multiplexing (WDM) system including an array of multiple optical signal generators each for generating an optical signal having a peaked spectrum function including a center wavelength, and, a corresponding array of optical filter elements, an optical filter element of said array on one to one correspondence with an optical signal generator for receiving and filtering a corresponding optical signal.

12. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 11, wherein said wavelength-locked loop servo-control circuit includes array control device for enabling real time alignment of an optical signal center wavelength of a specific optical signal generator in said array with said peaked passband function of its corresponding optical filter in said filter array, each said optical signal center wavelength capable of being aligned at a wavelength corresponding to maximum overlap with said center wavelength of said peaked passband function of its respective said optical filter for maximum transfer of said output optical signal by said filter element and minimum overlap with said peaked passband function of said optical filter so that said output optical signal may be attenuated in said optical system.

13. The apparatus for attenuating optical signals communicated in an optical network as claimed in Claim 12, wherein said wavelength-locked loop servo-control circuit provides gain equalization function by enabling specific channels in said WDM system to be attenuated in a controlled pattern.

14. A method for attenuating optical signals communicated in an optical network comprising the steps of:

a) providing optical signal generator for generating optical signals, each optical signal having a peaked spectrum function including a center wavelength;

b) providing optical filter element for receiving and filtering an optical signal, said optical filter element exhibiting a peaked passband function including a center wavelength; and,

c) enabling real time alignment of said optical signal center wavelength with said peaked passband function of said optical filter, said optical signal center wavelength capable of being aligned at a wavelength corresponding to maximum overlap with said center wavelength of said peaked passband function of said optical filter for maximum transfer of said output optical signal by said filter element and minimum overlap with said peaked passband function of said optical filter so that said output optical signal may be attenuated in said optical system.

15. The method as claimed in Claim 14, wherein said step c) of providing real-time alignment further comprises the steps of:

applying a dither modulation signal at a dither modulation frequency to said optical signal to generate a dither modulated optical signal through said optical filter element;

converting a portion of dither modulated optical signal to into an electric feedback signal;

continuously comparing said feedback signal with said dither modulation signal and generating an error signal representing a difference between a frequency characteristic of said feedback signal and a dither modulation frequency; and

adjusting the peak spectrum function of said optical signal according to a desired amount of optical signal attenuation and said error signal, wherein said center wavelength of said optical signal is adjusted to comprise a center wavelength ranging between said maximum overlap and minimum overlap with said center wavelength of said peaked passband function of said optical filter.

16. The method as claimed in Claim 15, further including the step of:

providing a laser diode device for generating a laser signal; and,

providing a bias signal to said laser diode device for adjusting a peak spectrum function of said laser signal, wherein said adjusting step includes adjusting a center wavelength characteristic of said laser signal according to a value of said error signal plus an offset corresponding to a desired amount of optical signal attenuation.

17. The method as claimed in Claim 16, wherein said step of adjusting a center wavelength characteristic of said laser signal includes the steps of:

implementing a look-up table comprising values of error signals mapped to laser bias signal values corresponding to desired degrees of attenuation, said center wavelength of said laser signal being adjusted in accordance with said mapped laser bias signal values.

18. The method as claimed in Claim 16, wherein said step of continuously comparing said feedback signal with said dither modulation signal comprises:

combining said converted feedback signal with said dither modulation signal and generating a cross-product signal having components representing a sum and difference at dither frequencies.

filtering said output cross-product signal; and

averaging said output cross-product signal to generate said error signal, said error signal being positive or negative depending on whether a center wavelength of said amplified optical signal output is respectively less than or greater than a center wavelength of said peaked passband optical filter function.

19. An apparatus for providing gain equalization in a wavelength division multiplexing system comprising an array of optical signal generators each for generating an optical signal having a peaked spectrum function including a center wavelength, and a corresponding array of optical filter elements, each filter element for receiving and filtering a corresponding optical signal from said optical signal generator array, each said

optical filter element exhibiting a peaked passband function including a center wavelength, said apparatus comprising:

a wavelength-locked loop servo-control circuit for enabling real time alignment of each said optical signal center wavelength generated by said optical signal generator array with said peaked passband function of its respective optical filter element in said filter array, each said optical signal center wavelength capable of being aligned at a wavelength corresponding to maximum overlap with said center wavelength of the peaked passband function of its respective optical filter for maximum transfer of said output optical signal by its respective filter element and capable of being aligned at a wavelength corresponding to minimum overlap with said peaked passband function of its respective optical filter so that said output optical signal may be attenuated in said optical system.

20. The apparatus for providing gain equalization in a wavelength division multiplexing system as claimed in Claim 19, wherein said wavelength-locked loop servo-control circuit comprises:

a mechanism for applying a dither modulation signal at a dither modulation frequency to each said optical signal of said array to generate a plurality of dither modulated optical signals for transmission through its respective optical filter element;

a mechanism for converting a portion of each dither modulated optical signal to into a corresponding electric feedback signal;

a mechanism for continuously comparing each said feedback signal with said dither modulation signal and generating a respective error signal representing a difference between a frequency characteristic of said feedback signal and a dither modulation frequency; and

a mechanism responsive to each respective error signal for adjusting the peak spectrum function of its corresponding optical signal according to a desired amount of optical signal attenuation, wherein a center wavelength of each said optical signal is

adjusted to comprise a center wavelength ranging between said maximum overlap and minimum overlap with said center wavelength of said peaked passband function of its respective optical filter.